Cruzane Mountain

Vegetation Report

Prepared by:
Andy Kies
Silviculturist

for:
Superior Ranger District
Lolo National Forest

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Introduction

The analysis for the forest vegetation resource focuses on how the alternatives would affect the tree species composition and structure of the forest stands (treatment units) in the Cruzane Mountain project area and how those effects would influence the resilience of forest vegetation to future disturbances and stressors (e.g. insects and diseases, wildfires, droughts, etc.). The Cruzane Mountain project area is prone to and has been impacted by eight biotic disturbance agents: mountain pine beetle, western spruce budworm, dwarf mistletoe, white pine blister rust, Douglas-fir beetle, fir engraver beetle, elytroderma needle cast, and root disease, primarily Armillaria root rot. After several large fires during the first half of the last century, much of the project area was reforested with stock that was not adapted to local conditions. Some of the trees that originated from this "off-site" stock are beginning to succumb to pathogens that are not normally lethal, for example, elytroderma needle cast in ponderosa pine. Douglas-fir dominated stands are at an elevated risk for Douglas-fir beetle, especially if they have any amount of root disease. This report explains why the Forest Service seeks to treat areas in the Cruzane Mountain project area at this time.

National, Regional and Forest policies and scientific literature describe the tree composition and structure that is desired in order to improve the resilience of the forest vegetation, and this report includes information to evaluate how well the alternatives would trend the vegetation towards those conditions.

Management direction that is relevant to the topic of forest vegetation is evaluated to determine if the alternatives would be consistent with direction in the Forest Plan as well as other policy, regulations and laws. Also, the report was designed to provide information that is needed in order to evaluate how well the various alternatives meet the purpose and need of the project.

The purpose and need for the Cruzane Mountain Project is directly related to the forest vegetation resource. The overall purpose of the project is to reduce stand density, and increase heterogeneity (age class, size class, and species diversity) to increase forest health; reduce fuels, and reduce the effects of having off-site trees planted in the project area after large fires during the first half of the last century. This report will address how well the proposed actions address these objectives and those discussed under the purpose and need section below.

This analysis will focus on the direct and indirect effects of implementing intermediate and regeneration harvests to forested stands in the project area. Direct effects are those that occur at time of treatment, where the treatment takes place; indirect effects are those that take place later in time than the treatment and/or in a different location.

Topics and Issues Addressed in This Analysis

Topics and issues addressed in this report were briefly mentioned in the introductory section of this report. Additional detail is provided below as it relates to the purpose and need, measures and indicators that are used to determine how the two alternatives affect topics and issues.

Purpose and Need

The purpose and need for the Cruzane Mountain Project is directly related to the forest vegetation resource. The purpose and needs for the Cruzane Mountain Project are:

- Reduce insect and disease hazard and risk by: reducing forest density in ponderosa pine stands to levels consistent with a "low" bark beetle hazard rating; establishing and featuring root disease resistant species on sites with root disease; reducing forest density and shifting towards non-host species to develop and maintain stands with low Douglas-fir beetle hazard; and develop species and age class diversity in lodgepole pine stands susceptible to or already affected by mountain pine beetles to reduce hazard and future susceptibility.

- Reduce hazardous fuels and increase fire suppression safety and efficiency.
- Reduce the dysgenic effects of poorly adapted trees established from off-site seed sources following the 1910 fire and fire from the mid-1930s, which have increased susceptibility to common insects and diseases resulting in uncharacteristic stand damage and mortality.
- Provide timber and other forest outputs.

Desired conditions for this project area are:

- Make more resilient vegetation communities, with resiliency defined as: the capacity of a plant community or ecosystem to maintain or regain normal function and development following disturbance (Helms, 1998)
- Reduce insect and disease activity through indirect control methods.
- Create a higher proportion of early seral species, primarily western white pine, western larch, and ponderosa pine.
- Remove trees that are spreading off site genetic material that are creating downward pressure on the native gene pool.

Specific desired conditions for each forest type are described below.

Other Resource Concerns

There were a wide range of concerns brought forward by the public. One group would like the Forest Service to treat more aggressively in terms of number of acres treated, amount of residual stocking left post-treatment, and increasing the number of areas considered for treatment to include riparian zones. Other commenters would like the Forest Service to consider how a lack of active forest management in the area has led to current insect and disease and fuel loading problems. One commenter would like the Forest Service to disclose how much old growth is in the project area.

The amount of harvest and acres considered for harvest are the result of field reconnaissance, examining past treatment acres, and considering all relevant laws, regulations, and policies. Existing conditions are generally described in terms of past management activities, including past fire suppression. It is difficult to quantify the extent to which lack of past harvest has influenced current conditions due to the potential variability in treatments that did not happen; therefore, the hypothetical treatments that did not take place are not considered in describing existing condition, except for the management action of fire suppression. The percent old growth at the landscape level will be disclosed.

Resource Indicators and Measures

Resource indicators are metrics sensitive to change relative to the proposed action. They are derived from the project purpose and need and public input, and are bound by laws, regulations, and policies. Table 1 lists the resource indicators and detail about each indicator, followed by an explanation of some of the terms used in the table.

Table 1. Detailed resource indicators.

Resource Indicators		
Resource Element	Resource Indicator	Measure
structure	density	trees per acre
		basal area
	size class	quadratic mean diameter
	number of stories	number
resilient species	species composition	% of early seral species
genetic makeup	genetic component	% off-site trees present

Density is defined by trees per acre (TPA) and/or basal area (BA). Basal Area is defined as the cross sectional area, in square feet, of all trees at diameter at breast height (DBH), which is defined as the diameter of a tree four and one half foot above the ground, on a per acre basis. Generally, in stands with trees less than five inches DBH, TPA will be used. In stands dominated by larger trees, BA will be used to describe density. One of the purposes of this project is to lower densities to those that are consistent with low beetle hazard ratings. (Helms, 1998)

Size class will be defined by quadratic mean diameter (QMD), which is the diameter of a tree with the average basal area within a stand, measured on a per acre basis. In most of the stand types, it is desirable to increase QMD. (Helms, 1998)

Species composition is the percent of a stand made up of different species, this can be defined by the total TPA or BA that one species represents as a percent of the total TPA or BA within a stand.

Genetic Component for this project will be defined by the percent of a stand that has off-site trees planted in the first half of the last century. We will rely on phenotypic traits to determine which trees are off site. In this case, that will generally be large ponderosa pine for their age that are succumbing to what are normally non-lethal diseases.

Methodology

The methods, science, and assumptions that are used for the analysis in this report are noted in individual sections of the report. This vegetation report incorporates stand, project level, and landscape level data sets and analysis. The landscape name that the project lands in for FIA analysis (see below) is called St. Regis-Prospect. A stand is defined as: “a contiguous group of trees sufficiently uniform in age class distribution, composition, and structure, and growing on a site of sufficiently uniform quality to be a distinguishable unit, such as mixed, pure, even-aged, and uneven-aged stands. A stand is the fundamental unit of silviculture reporting and record-keeping.” (Forest Service Handbook 2470) Stands make for finer resolution analysis; stands or portions of stands are ultimately aggregated into treatment units. Treatment units for this project are listed in Appendix A of the environmental assessment. Project level analysis is that which occurs in the Cruzane Mountain project area.

Forest vegetation is dynamic, data discussed below is assumed to describe current conditions. Where it is known this is not the case, it will be noted. Analysis in this document is based on the fact that forest ecosystems evolve with disturbance including altered fire frequency and severity, insects, and diseases. Relationships between climate, natural disturbance, and human activities are synergistic and complex forces that influence vegetation structure, pattern, and condition.

Information Sources

Existing vegetation data discussed in this report are from four sources: two landscape level and two stand level, which are both discussed below. Minor data discrepancies can be found between these data sets, this is the result of examining different scales, clipping geographic information system data to slightly different boundaries, different data collection techniques, and the realities of comparing remotely sensed data to field sampled data. Species composition and tree size class trends are the same for all data sets. Further information on each data set can be found in the references cited below.

Landscape Level Data

Region 1 VMap

Region 1 vegetation mapping classification database (VMap) is a remotely sensed existing vegetation database that houses calculated values for lifeform, dominance type, tree size class, and tree canopy cover. Software is used to break landscapes up into discreet, homogenous polygons and the aforementioned attributes are applied to each polygon. This product is updated periodically. The latest version that the Lolo National Forest is currently using is from 2017.

Forest Inventory and Analysis data

Forest Inventory and Analysis is a system of plots that fall randomly on all ownerships across the United States; measured attributes include: species, size, forest health indicators, down woody material information, trees per acre, and habitat type. Some of these attributes are used to calculate ancillary metrics such as dominance type, canopy cover, basal area per acre, trees per acre, and various insect and disease hazard ratings. Forest Inventory and Analysis data is summarized via the Region One Forest Inventory and Analysis Summary Database and used to characterize the St. Regis-Prospect landscape that this project falls within. A file displaying this landscape is in the project record.

Stand Level Data

Walkthrough Diagnosis

This is data collected according to the Forest Service Manual, chapter 2470. The purpose of the diagnosis is to determine existing stand conditions and how these may or may not depart from desired conditions, and whether or not it makes sense to treat now or defer treatment to achieve a desired condition (U.S. Department of Agriculture, 2014).

FSVeg/FSVeg Spatial

FSVeg houses field sampled vegetation such as tree species, age, size class, crown ratio, fuel loading information, habitat type, etc. this data is summarized on a per acre or per stand basis and geographically displayed in FSVeg Spatial. Habitat type and habitat type groups were derived from FSVeg Spatial and field checked during the walkthrough diagnosis phase and determined to be sufficiently accurate.

Activity Data

Forest Service Activity Tracking System (FACTS)

Past activity data is from the Forest Service Activity Tracking System. This houses information on past harvest, planting, commercial and pre-commercial thinning, burning, fires and other activities that have taken place in the project area.

Information that is incomplete or unavailable will be noted. Future disturbances in the form of wildfire, insects and disease, and climate change could change vegetation conditions in the future, estimates of those potential changes are not given in this report. See the Carbon Cycling and Storage Report in the project file for more information on information and effects of climate change. Note that climate change may alter successional pathways from how they are understood and explained in some of the citations in the document. The best way we currently know how to deal with this is to increase the overall resiliency of the project area and broader landscape.

Spatial and Temporal Context for Effects Analysis

The spatial boundaries for analyzing the direct, indirect, and cumulative effects to vegetation are partially discussed above in the data section; the project boundary is large enough to capture the effects of treatment to the vegetation resource in terms of changes to stand structure and composition, and age/size class distribution. Timber sale outputs can also be assessed at this level. Occasional reference will be made to a much larger landscape in this report. The project is part of a broader landscape and necessarily impacts that landscape. Refer to the project record and the data discussion for an explanation of the landscape area.

The temporal boundaries for analyzing the direct and indirect effects are 5 to 50 years into the future, because that is how long the effects are anticipated to last. Harvest treatments would likely last longer than certain burning treatments. Future fire management decisions will influence how long treatments last as well. Current conditions reflect the cumulative effects of past activities.

Affected Environment

Existing Condition/Desired Conditions

Existing vegetation conditions can be described in multiple ways. For this project, habitat types will be grouped into broad habitat types groups called R1 Habitat Type Groups (Milburn, Bollenbacher, Manning, & Bush, 2015), these groupings are very similar to those found in the document used to define old growth in Region One (Green et al., 1992). Habitat typing is a method of classifying vegetation based on associations that exist between tree and grass/forb/shrub species and how those vegetation communities will progress through time into late seral species mixes through a process called succession. Successional pathways described by habitat typing exist in the absence of disturbance, but habitat type manuals provide information on natural disturbance regimes and how these regimes would alter successional pathways (Pfister, Kovalchik, Arno, & Presby, 1977). Figure 1 displays the habitat type groups by treatment unit in the project area.

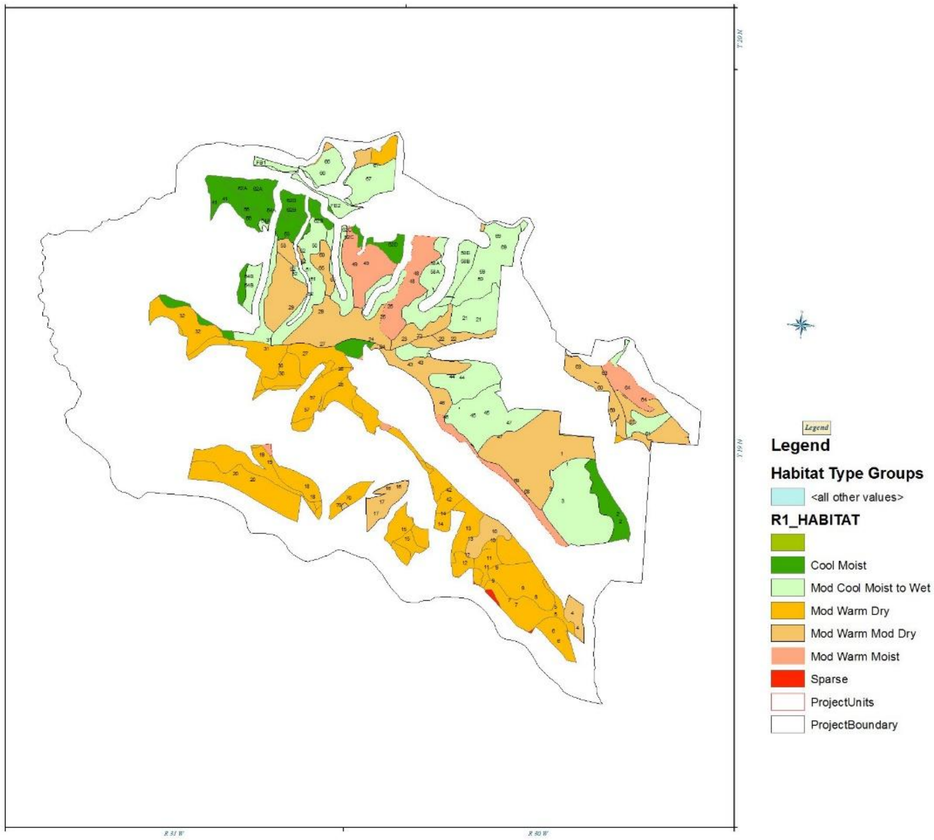

Figure 1. Habitat type groups by treatment.

The Cruzane Mountain project area has two main forest types, dry ponderosa pine/Douglas-fir dominated and western larch/western white pine dominated. The dry ponderosa pine/Douglas-fir type is comprised of the moderately warm dry and moderately warm and moderately warm dry habitat type groups and the western larch/western white pine type is comprised of the moderately cool moist to wet and cool moist groups. The moderately warm moist habitat type group is more transitory and can fall into either category depending on more specifically defined site conditions. Each is discussed further below.

Desired conditions for each vegetation type are discussed below. Creating landscape level heterogeneity for each vegetation type in terms of structure, age class, and composition is the best way to achieve large scale resilience to biotic and abiotic stressors (Newton & Cantarello, 2015) (Charnley, Spies, Barros, White, & Olsen, 2017). Resilience is defined in the Forest Service Handbook as:

> "The ability of an ecosystem and its component parts to absorb, or recover from the effects of disturbances through preservation, restoration, or improvement of its essential structures and functions and redundancy of ecological patterns across the landscape." (U.S. Department of Agriculture, 2015)

In trying to plan for an uncertain climatic future, it is best to leave multiple options available to future land managers to allow for adaptation to changing conditions, while still reducing the impact of immediate threats (Turner, Donato, & Romme, 2012). Maintaining legacy structure, defined as structure that takes multiple stand rotations to create is important for maintaining landscape and within stand heterogeneity, which helps lead to resiliency (Franklin et al., 2002). Additionally, any trees of any species that exhibit off-site characteristics such as near-lethal elytroderma needle cast infections will be removed to restore a gene pool that is adapted to this site. Past harvest has also likely played a role in degrading the on-site gene pool by consistently selecting the best phenotypic trees and leaving less desirable trees on site (Finkeldey & Ziehe, 2004).

Forest Types

Dry ponderosa pine/Douglas-fir forest types

This type exists mostly on the south side of the project area facing Interstate 90 and transitions into a cooler type on the ridge top that incorporates Cruzane Mountain. The north side of the project has inclusions of this type on more westerly facing slopes and flat bottoms on the northwest side of the Packer Creek road (#288). Within this vegetation grouping, drier areas tend towards ponderosa pine and moister, cooler areas tend towards Douglas-fir, both with larch and other species inclusions.

Primary agents of disturbance in these types are bark beetles and wildfire. Of the two factors, wildfire poses the more immediate threat to the resilience of these forest types. These types historically had low- and mixed-severity wildfire with occasional stand-replacing wildfire (Applegate et al., 1997) (Fischer & Bradley, 1987).

Many years of fire exclusion and harvesting the largest trees out of these forest types have changed the distribution of size classes and species composition within this group to one with smaller trees, higher canopy cover, more stories, and more late seral species (Naficy, Sala, Keeling, Graham, & DeLuca, 2010). This has increased susceptibility to stand replacing fire because with more small trees, it is easier for fire to move from the surface into the crown and late seral species such as grand fir and mountain hemlock are less adapted to surviving wildfire. Shifting fire frequency and intensity to longer intervals with higher intensity can lead to a change in how these ecosystems function (Hessburg, Agee, & Franklin, 2005) (Fitzgerald, 2005). The change in function from how they traditionally worked is not desirable and can lead to widespread ecosystem degradation. Western spruce budworm is much more prevalent because of the increased number of susceptible hosts (Douglas-fir/grand fir) and more conducive stand conditions (multi-story, weakened trees) (Pederson, Sturdevant, & Blackford, 2011). Stocking that is higher than how these stands evolved leads to stressed trees that are less able to fend off insects and disease. Douglas-fir beetle and western pine beetle, both of which tend to infect larger trees are currently experiencing increased populations within the project area (Kegley, 2011) .

Desired conditions in these types is to shift fire type from crown, stand replacing fires to surface and mixed severity fires. Species composition will shift much more toward ponderosa pine and structure will be simplified, with less stories, but still maintaining a spatially heterogeneous distribution of size classes of appropriate species. At the stand level, there will be variability in distribution of size classes and spacing of trees and there will be more open areas. At a landscape level, a mix of successional stages will exist from seedling/sapling stands to old forest condition stands. Current conditions would generally support crown and stand replacing fires,

while desired conditions would allow for surface fires only lethal to most of the smaller trees in a stand. (Hessburg et al., 2005) (Larson, Belote, Cansler, Parks, & Dietz, 2013)
Other desired conditions are:

- Maintain 5-15 tons per acre of down woody material.
- Regenerated stands will have stocking levels of 50 to 150 trees per acre depending on specific site conditions and proximity to private property/structures.
- Basal areas will be in the range of 40 to 80 if enough trees of desirable species, health, and phenology are available. If not, stands will typically be regenerated and planted to an appropriate stocking level of appropriate species.
- Removal of off-site trees.
- Increase size class to a higher quadratic mean diameter.

Western larch/western white pine forest types

Wildfire is the primary native agent of disturbance in larch and historic western white pine forest types. Wildfire was historically highly variable with low-, mixed-, and high-severity in mountain landscapes like the Cruzane Mountain project area (Barrett, Arno, & Key, 1991). White pine blister rust is very important, highly impactive, non-native pathogen that weakens and kills western white pine (Burns & Honkala, 1990); (Maloy, 2001). The Cruzane Mountain project area has been heavily influenced by white pine blister rust by severely reducing the amount of western white pine that historically existed in this area.

In the project area, fire exclusion and vegetative development have resulted in more homogenous conditions favorable to high-severity wildfires. Field assessments indicate that there was a higher component of western larch and western white pine within portions of the project area based on very old stumps and surviving legacy trees, prior to the large scale fires and introduction of white pine blister rust that occurred around the turn of the 20th century. These areas have grown back predominantly to grand fir, hemlock, and lodgepole pine with a substantially lower proportion of western larch and western white pine. After about 100 years, the lodgepole pine trees are of a size and age that makes them highly susceptible to mountain pine beetles. Past and on-going mortality in the lodgepole pine resulting from bark beetles has created a need to restore western larch, which is a more insect, disease, and fire-resistant tree species (Arno, Smith, & Krebs, 1997). Western larch is the most shade-intolerant tree in the project area and needs open space and sunlight to thrive. Fire exclusion has also allowed development of dense understories of shade-tolerant tree species (e.g. Douglas-fir, grand fir, and subalpine fir) in western larch stands resulting in increased risk of stand-replacing wildfires.

Historically, western white pine dominated the moist, mid-elevation, mixed-species forest between 2,000 and 6,000 feet in the Inland Northwest (Fins et al. 2001). As of the 1960s, western white pine has nearly disappeared from the landscape. The introduced pathogen white pine blister rust, high-grading, mountain pine beetles, and fire-exclusion policies have all contributed to its decline. Western white pine relies on large openings from stand replacing fires or harvest to provide regeneration opportunities. In northwestern Montana, including the Cruzane Mountain project area, western white pine has been replaced by Douglas-fir, lodgepole pine, and grand fir, which are more susceptible to insects and diseases (Fins et al. 2001).

Restoring resilience in these forest types means re-establishing variable stand structures and species compositions that are more likely to support low- and mixed severity wildfire in the future and are more resistant to biotic and abiotic threats. Specifically, this means increasing the percent of western larch and rust resistant western white pine while reducing the amount of lodgepole pine and of shade tolerant grand fir, subalpine fir, and western hemlock.
Specific desired conditions are:

- Reduce the number of stories from multi-story to one or two story.
- Reduce basal area to 40 to 80, where enough desirable trees exist. Where they do not exist, regenerate the unit and plant to desirable stocking levels and species compositions.
- Reduce TPA to 50 to 200 depending on size class.
- Increase the amount of rust resistant western white pine and western larch.
- Increase overall size class to a higher quadratic mean diameter.

Snags

The Lolo National Forest follows two sets of snag policies. The Forest Plan has snag retention guidelines and an ancillary document titled Lolo National Forest Dead and Down Habitat Components Guidelines, June 1997 provides additional direction on the Forest Plan direction (U.S. Department of Agriculture, 1997). Both will be followed. Snag analysis for the project area can be found in the wildlife report.

Existing Vegetation

Existing vegetation will be described using V-Map data, which is described above. One of the attributes available in V-Map is dominance type, this is a metric that is in the Region One Existing Vegetation Classification System (Barber, Berglund, & Bush, 2009), which is based on National Technical Guide guidance. Dominant 40 is one of the dominance type classifications that is available in V-Map, it is a way to describe existing vegetation by species cover that represents at least 40 percent of the V-Map polygon. Lifeform indicates the predominate lifeform within a V-Map polygon (Barber, Bush, & Berglund, 2011).

Coniferous trees dominate the lifeform distribution within the project area, covering over 91 percent of the area; all lifeforms are displayed in Table 2 below:

Table 2. Percent lifeform within project area

Lifeform	Percent of project area
HERB	1.97%
SHRUB	1.08%
SPVEG	4.30%
TREE	91.40%
TREE-DECID	0.18%
WATER	1.08%

Douglas-fir dominates the species distribution within the project area, as demonstrated by Figure 2 below:

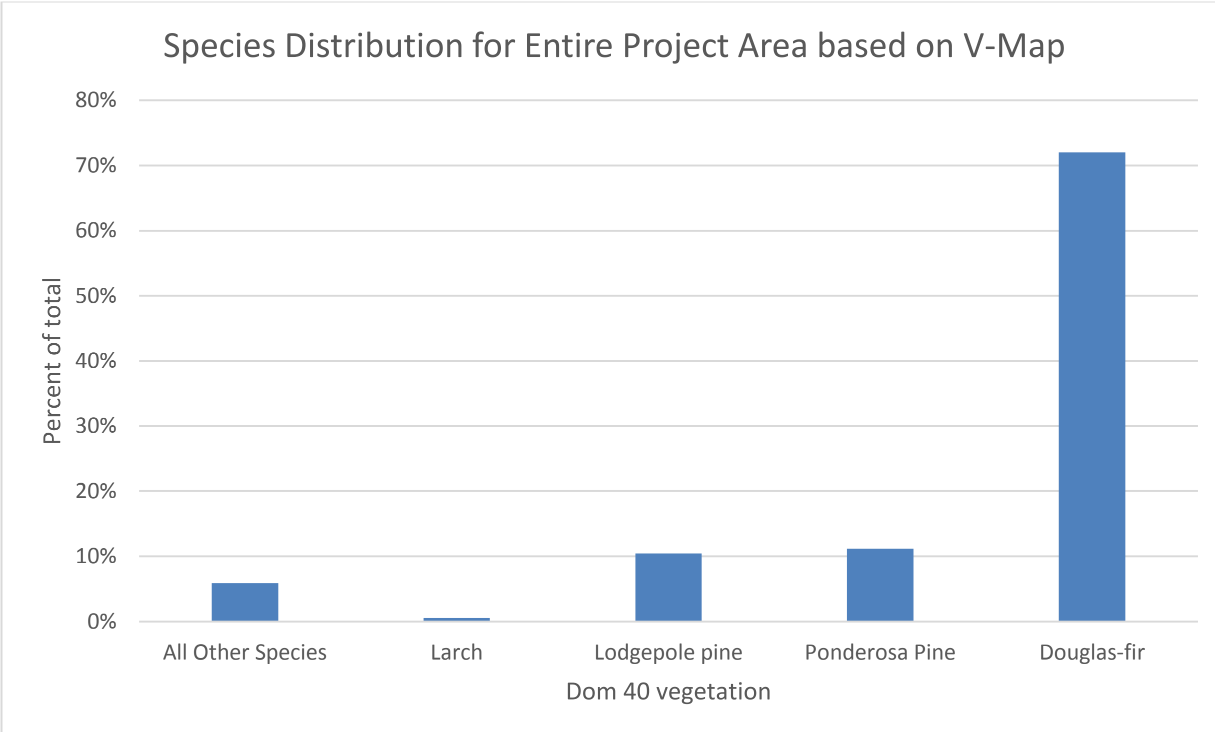

Figure 2. Species distribution within the Cruzane Mountain project area

Despite the habitat type grouping discussed below, western larch and ponderosa pine currently represent a very small percentage of the overall project area. Note that Group 2 represents shrubs, other non-tree lifeforms, and tree species that are represented by very low percentages.

Size class distribution

Most of the forested portion of the project is in the 10-15" size class, there is little representation of the largest and smallest size classes (Figure 3).

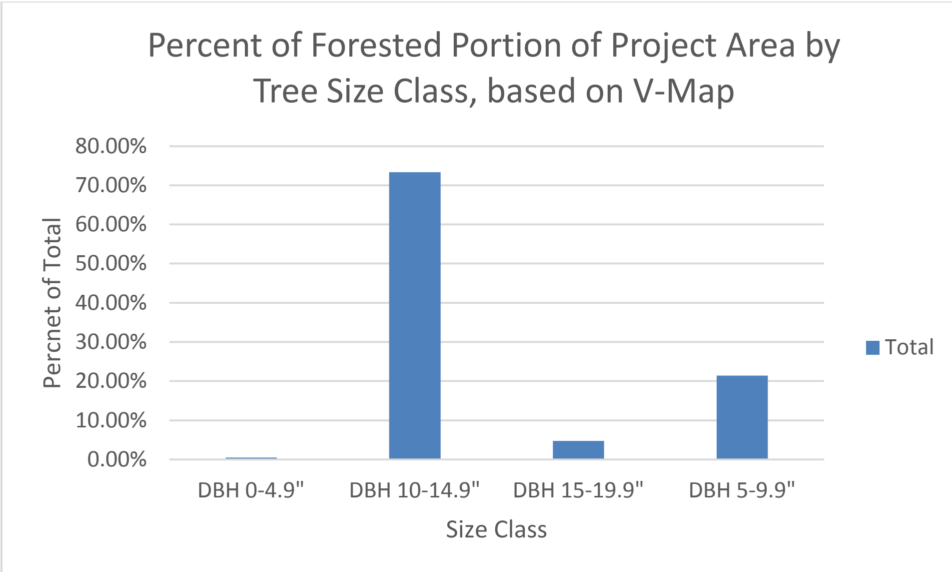

Figure 3. Tree size classes with in the project area

Old Growth

Each area proposed for treatment has had a stand diagnosis completed, an assessment of old growth status was part of this assessment. Most of the project area burned in the early part of the last century; therefor there is little old growth within the project area as computed at the stand level. No old growth is proposed for treatment within this project area. The types of treatments that will be implemented will retain healthy large early seral species which will help to create future old growth stands in less time than un-managed stands and that are more resilient to insects and disease. The overall resiliency of the larger landscape that the project lands within will help ensure that any old growth that may be adjacent to the project area will be more likely to survive insects, pathogens, and fire.

According to Forest Inventory and Analysis data approximately 6 percent of the St. Regis-Prospect landscape is old growth.

Threats: Insect, Disease, Genetic Erosion

Four insects are or are in danger of impacting the project area: mountain pine beetle, western spruce budworm, fir engraver beetle, and Douglas-fir beetle. The pathogens: root disease, elytroderma needle cast, white pine blister rust, and dwarf mistletoe are common in the project area. Following major fires in the early part of the last century, many acres were planted with off-site seedlings that are not adapted to the site. Each of these threats is described in the following sections.

Root Disease

Armillaria root rot is a site disease that is very active in the project area. Its primary host(s) is Douglas-fir and true firs on warm moist sites. As shown in Figure 2 above, Douglas-fir dominates the species composition at the project level with 72 percent dominance. Infection rates in the project area are high within Douglas-fir, affecting multiple size and age classes. Many of the sites infected with root rot were historically stocked with much less susceptible species such as ponderosa pine and western larch, so the increase in the prevalence of root disease has more to do with long term species conversion than proliferation of the disease. (S. Hagle, 2004)

Figure 4 demonstrates the mycelial fans associated with the fungus that infects and causes rot in root systems of host species.

Effective root rot control is accomplished through promoting non-host species such as western larch, ponderosa pine, and western white pine. Generally, root rot infections were historically lower on the Superior Ranger District because there were more root rot resistant species when fire was allowed to burn more freely (Losensky, 1993).

Figure 4. Mycelial fan associated with root rot in Douglas-fir

Elytroderma Needle Cast

Elytroderma needle cast is a foliage disease that causes brooming and mortality of last year's needles, primarily in ponderosa pine and less so in lodgepole pine. Normally, this disease is not lethal, but in this project area it is causing mortality, largely in what are believed to be off-site ponderosa pine trees planted after the 1910 fire (Figure 5). (Hoffman, 2004)

Elytroderma control specific to this project area involves removing off-site trees that are succumbing to the disease and planting site appropriate trees.

Figure 5. Elytroderma needle cast broom on ponderosa pine

Larch/Lodgepole Pine Dwarf Mistletoe

The Lolo National Forest in general and west side of the Forest in particular have significant larch dwarf mistletoe infections. Dwarf mistletoe is a parasitic plant relying on its host to survive. Reliance on the host tree weakens the host and makes it more susceptible to other stressors. Further, dwarf mistletoe leads to "brooming", these brooms can be quite flammable and spread fire into the crowns of trees. (2010) Infection rates in the project area are localized, there are larch stands with heavy infections and stands with few infections. Figure 6 below shows dwarf mistletoe brooming in western larch in the project area.

Lodgepole Pine Dwarf Mistletoe exists in the project area, but is limited in distribution and many of the live lodgepole pine hosts were killed in the last mountain pine beetle attack. This is not a major pathogen in the project area, but is present.

Mistletoe spreads by launching seeds with hydraulic pressure up to 20 feet from fruits. This can infect adjacent uninfected trees. Levels of infection are based on the Hawsksworth system, which is a scale from 0-6, with 0 having no infection and 6 being fully infected. Tree canopies are broken into three equal length discrete sections vertically and each section is assigned an infection rating from 0 to 2. Each of the three ratings is then added together to reach a final rating of 0 to 6. Ratings for 3 or higher generally mean that tree must be removed to slow the spread of infections among other susceptible trees in the stand. (Hawksworth, 1977)

Control of heavily infected stands requires regenerating the stands and starting a new age class that can be managed into the future. Thinning can exacerbate latent infections. Regeneration units must be sufficiently large and of proper shape to ensure that the ratio of edge to acres is large enough to ensure new infections will not come from adjacent stands. Generally, 20 acres units that are not linear in shape is the bare minimum size to prevent infections from potentially infected adjacent stands from entering the treated stand. New stands can be managed into the future as stands with multiple age classes if desired (Hoffman, 2010).

Figure 6. Dwarf mistletow in western larch.

White Pine Blister Rust

White pine blister rust is a non-native fungal disease that infects five needle pines (western white pine, limber pine, whitebark pine) that was introduced to the western United States in 1910. The rust causes stem and branch cankers (Figure 7), any material beyond the canker eventually dies and most often, the entire tree dies. It causes up to 90 percent mortality in western white pine stands. In the Cruzane project area, restoring white pine can best be accomplished by planting genetically resistant stock on appropriate sites and managing the stands into the future with pruning and thinning (Schwandt, Kearns, & Byler, 2013) .

Intensive management like pruning white pine plantations and cutting out bole cankers can be effective at mitigating white pine blister rust, but the most effective way is to have a successful genetic resistance program with successful out year planting.

Figure 7. Canker from white pine blister rust

Mountain pine beetle

Mountain pine beetle (MPB) primarily impacted lodgepole pine stands in the project area. The project area consists of about 10 percent lodgepole pine, most of the stands that are of susceptible size classes (>5-8 inch DBH) were heavily impacted during the last mountain pine beetle epidemic which lasted from about 1999-mid 2000s (K. Gibson, 2009). Some ponderosa pine was impacted by mountain pine beetle, but to a lesser extent than lodgepole pine. Western white pine can be impacted by mountain pine beetle, but such infections tend to be rare because most susceptible sized white pine has been killed by blister rust (K. E. Gibson, 2004).

MPB will probably always exist in endemic amounts in the project area; however, it is desirable to prevent another epidemic like the one that ended in the mid-2000s and affected many susceptible stands in Region One. Creating a mosaic of age classes in lodgepole pine stands helps to prevent all stands from being susceptible at the same time (Gillette, Wood, Hines, Runyon, & Negrón, 2014). Reducing basal area below 80 in ponderosa pine stands lowers hazard ratings. Western white pine has not appreciably been affected in the project area, but as rust resistant trees are planted and mature, they may become susceptible to MPB. If this happens, adaptive management strategies such as experimental thinning may be called for (K. E. Gibson, 2004).

Western spruce budworm

Western spruce budworm has infected many mature Douglas-fir and most of the Douglas-fir and grand fir understory in the project area; heaviest infestations exist in multi-story stands dominated by Douglas-fir. Infestations are generally lighter in the upper canopy and heavier in the lower canopy of Douglas-fir. While western spruce budworm is not as big of a concern as root rot or Douglas-fir beetle, it does slow tree growth, can cause deformities, negatively affects seed production, and after cycles of defoliation can cause mortality, even in larger trees (Pederson, Sturdevant, & Blackford, 2009). Note that there are a very few individual large Douglas-fir trees that have much greater levels of defoliation than other similar size trees. These individuals may have such heavy defoliation because they are genetically susceptible to western spruce budworm, have other unseen diseases that are weakening the tree's defense mechanisms, or are on poor microsites. Finally, western spruce budworm is often weakens trees and pre-disposes them to infection by Douglas-fir beetle (Hadley & Veblen, 1993).

Maintaining stands with less than 50 percent Douglas-fir, grand fir, subalpine fir, or Engelmann spruce, maintaining basal areas below 80 with less than 100 trees per acre and that are single story lowers a landscape and an individual stand's susceptibility to western spruce budworm.

Douglas-fir Beetle.

Stands with higher percentages of Douglas-fir that are older and larger and have high stocking levels are at the highest risk for Douglas-fir beetle infestation. Western spruce budworm and root rot weakened trees are also more susceptible to Douglas-fir beetle. Blowdown of large live Douglas-fir can attract Douglas-fir beetle and cause a population to build; under ideal weather conditions, the building population can become an outbreak and infect many acres of mature Douglas-fir.

Maintaining basal areas below 115, species composition with less than 50 percent Douglas-fir, and keeping at least a cohort within stands less than 14 inches DBH and less than 120 years old lowers a stand's susceptibility to Douglas-fir beetle. (Kegley, 2011) Removal of blown down live trees can also help prevent a buildup of the beetle, but this is not a practical control measure on a large scale.

Fir Engraver Beetle

Fir engraver beetle is a bark beetle that primarily attacks grand fir and occasionally subalpine fir in the project area. The results of a successful attack range from dead branches to complete mortality. In treatment units, most grand fir will be removed, which drastically lowers the stand's susceptibility. This is not a potent beetle at the project level (Randall, 2012).

Genetic Erosion

After the 1910 fires, there was a shortage of local seedling stock and transplanting zones were poorly understood. Seedlings were brought in from zones outside of the project area seed zone from as far away as California. The Regional geneticist visited the area in 1995 and concluded that there was "off-site" ponderosa pine planted and that it was succumbing to elytroderma needle cast. He recommended removing these trees to prevent them from spreading ill-adapted genes into the area. It is often quite obvious to determine which ponderosa pine are off site – they often grew very fast relative to native stock and are now dying from elytroderma needle cast (Howe, 1995).

There is evidence that some off-site western white pine was planted in the project area as well. Many of these trees have probably already died from white pine blister rust or other insects and diseases; therefore, are not as much of a concern as the off-site ponderosa pine.

Environmental Consequences

Direct and Indirect Effects

Direct and indirect effects on the vegetation resource will be evaluated by how effective the two alternatives are at meeting the purpose and need of the project. The proposed action alternative would trend the vegetation toward desired conditions described above. Stand structure, species composition, size class distribution, and genetic resistance would all fall into desired conditions and place stands of trees on a trajectory to approximate historic and desired fire return intervals. Direct effects of commercial actions (timber harvest) are anticipated to happen over the next one to ten years; direct effects of non-commercial actions would occur throughout the life of the NEPA document.

Alternative 1 – No Action

Continuing with the No Action alternative would trend vegetation conditions in the same direction they are currently trending. Consequences of this are as follows.

- Mid and late seral species would dominate the landscape.
- Species diversity, stand structure, and size class distribution would remain at current levels or fall further out of desired conditions. As such, the landscape that the project is in would be less resilient to disturbance and less diverse for wildlife. Landscape level homogeneity would increase and heterogeneity would decrease. Over time, in the absence of disturbance, species diversity would continue to shift towards late seral, shade tolerant and more insect and disease prone species such as grand fir, Douglas-fir, and hemlock. Western white pine would continue to fade out of the project area and larger ecosystem.
- Heavy fuel loading and ladder fuels would continue to be ubiquitous in the project area. Standing dead lodgepole pine would fall over at increasing rates, converting the fuel loading to a more lethal horizontal arrangement.
- There would be less potential for certain stands to reach old growth status due to succumbing to fire and insect and disease.
- All of the insects and diseases currently acting in the project area, would continue to attack trees and forest health at the project level would trend downward.
- The project area would continue to fall out of desirable conditions defined in the Forest Plan.
- Off-site genes would continue to spread throughout the project area.

The resource indicators and measures would remain unchanged or slowly degrade from the existing conditions as shown in Table 3.

Table 3. Resource indicators and measures for alternative 1

Resource Element	Resource Indicator	Measure	Effects on Resource Element
Stand Structure Species Composition Genetic Condition	Stand density/number of stories Species diversity Size Class diversity Removal of off-site trees	Trees per acre; Percent of project area dominated by western larch, ponderosa pine, and rust resistant western white pine Number of off-site	See above

Alternative 2 – Proposed Action

The proposed action is to implement 77 acres of pre-commercial thinning, create 15 acres of fuel breaks, 417 acres of commercial thinning, 13 acres of improvement cutting, and 981 acres of regeneration harvest. Commercial thinning and intermediate harvest is primarily being considered for the warm dry types while regeneration harvest is considered mostly for Douglas-fir stands with root rot infections and western larch/western white pine types. Many of the stands in the project area have either culminated or will not culminate as normally required by the National Forest Management Act due to persistent root rot and dwarf mistletoe infections. Fire exclusion, which has favored root rot host tree species, combined with root rot, which acts as a persistent intermediate treatment have created a situation where many of these stands will not culminate without being restored to a pre-fire exclusion, poor-root rot host species mix of western larch and ponderosa pine (S. K. Hagle et al., 2000), (Reukema & Bruce, 1977). Almost all of the regeneration units will be planted to some combination of western larch, western white pine, ponderosa pine, and rarely, Douglas-fir. Regeneration units that are not planted will rely on natural regeneration. If natural regeneration, which is monitored via regeneration inventory is unsuccessful, those units will be planted.

Prescribed fire is proposed for 1,161 acres within the warm dry ponderosa pine/Douglas-fir vegetation type, mostly on the north side (south facing) portion of the project area south of Interstate 90.

In addition to the effects discussed below by vegetation type, all of the proposed treatments will create a more heterogeneous landscape with more early seral species that are generally better adapted to fire and more resistant to insect and disease. Treatments will retain legacy structure, defined as structure that takes more than one rotation to create by generally leaving the largest early seral healthy trees, and appropriate snag and down woody material amounts (Franklin, Mitchell, & Palik, 2007).

Stand Structure and Species Composition

Intermediate Harvest Treatments

Intermediate harvest consists of pre-commercial thinning, commercial thinning and improvement harvest.

In all vegetation types, commercial thinning will help shift resources toward desirable leave trees, while removing undesirable seed sources and competition.

In dry ponderosa pine-Douglas-fir types, these types of treatments would heavily favor healthy ponderosa pine where it exists and discriminate against Douglas-fir, true firs, hemlock, and lodgepole pine. On sites where healthy larch is present, it would be favored.

The effect of this would be to shift stands towards healthy ponderosa pine dominated stands, which are far less susceptible to armillaria root disease, Douglas-fir beetle, western spruce budworm, dwarf mistletoe and reduce the amount of ladder fuels present. Stocking reduction would also lower the risk of mountain and western pine beetle attacks. It would also begin to restore the local gene pool be removing off-site ponderosa pine planted during the first half of the last century and by selecting for the best phenotypical trees of desirable species.

Generally speaking, this suite of treatments would change forest structure by shifting size class distribution up by favoring larger healthy ponderosa pine and larch. There are some instances where larger Douglas-fir would be removed in favor of smaller ponderosa pine or larch, but that would not be the norm. This would have the effect of increasing the likelihood that these stands would turn into old growth because the threat of biotic and abiotic stressors acting on these stands would be reduced (Arno et al., 1997) (Naficy et al., 2010).

Reducing stand density by lowering stocking stocking to levels considered to be low severity for mountain pine beetle or western bark beetle in ponderosa pine, will reduce basal area to 40 to 80 square feet, and maintain multi-aged stands. Stands with smaller trees can have higher basal areas and still retain beetle resistance than stands with larger trees that have advanced in structural stage (K. E. Gibson, 2004) (Bell Randall, 2004; Oliver & Larson, 1996).

Effects of intermediate harvest on western larch/western white pine dominated stands will be to lower stocking levels and shift species composition away from Douglas-fir, lodge pole pine, and grand fir and more towards western larch/western white pine. This will dramatically reduce the amount of armillaria root rot in the project area because western larch and western white pine have low susceptibility to this disease. Note that many of the stands dominated by this vegetation type have mistletoe infected larch, high percentages of Douglas-fir that is infected with armillaria root rot, and very little rust resistant western white pine; therefor, there are few acres of the vegetation type that will be treated with intermediate harvest.

Indirect effects of reducing this target basal area and removing most of the lower canopy layers are to lower both western spruce budworm and Douglas-fir beetle hazards (Pederson, 2011; Kegley, 2011).

Regeneration Harvest Treatments/Planting

Direct effects of regeneration harvest would be to remove most mature trees from a stand and leave trees required to meet forest snag and snag retention requirements. In almost all cases, these stands are heavily infected with root rot, mistletoe, western spruce budworm, are susceptible to Douglas-fir beetle, or have a high percentage of off-site ponderosa pine. Following removal, regenerated stands will be planted to a mix of species depending on site conditions. This will create young, generally two aged stands with a large component of seedlings and a smaller component of mature older trees. Because of the retained legacy structure and retention of live, healthy early seral tree species, most of the regeneration harvests will be creating early-successional forest ecosystems (Swanson et al., 2011). These, mixed with other treatment types and non-treated stands will help create a landscape with multiple successional stages, which, necessarily increases large scale resiliency.

Dry Ponderosa pine/Douglas-fir types will mostly be planted to ponderosa pine with wetter inclusions planted to western larch and in some instance rust-resistant western white pine. This will have the indirect effect of restoring these sites to species that used to be in much higher abundance, are more resistant to abiotic and biotic stressors, including fire.

Western Larch/western white pine types will be planted to western larch and white pine blister rust resistant western white pine. This will reduce mistletoe infections in western larch and increase the percent of western white pine in the project area. Indirect effects are to reduce the amount of white pine blister rust and lower mountain pine beetle hazards at the project level.

Resilience will go up as these resource indicators fall into a desirable range with implementation of the action alternative. Shifting species composition towards early seral species, creating more spatial heterogeneity in terms of size class distribution across the landscape will lower the overall susceptibility to a host of insect and diseases at the same time. Certain stands may have susceptibility at different times, but not the majority of the project area at one point in time, as it currently is.

Indirect effects not already discussed are to trend the entire landscape toward desired conditions in terms of species composition, size class diversity, insect and disease resilience, removal of undesirable off-site genes, and changing large scale fire behavior.

Effects of Openings

This project proposes to create three openings resulting from regeneration harvest that are greater than 40 acres in size. Information on the location and size of these openings was revealed at time of scoping. Forest Service Manual (FSM) 2470, Section 2471.1, Region 1 Supplement 2400-2016-1 generally limits the size of harvest openings to 40 acres or less. To exceed this size, Regional Forester approval is required except where natural catastrophic events (such as fire, windstorms, or insects and disease attacks) have occurred. Several regeneration harvest treatment areas could create forest openings that exceed 40 acres in size due to existing conditions (i.e. insects and disease). These larger openings could range in size from 123 to about 444 acres, mimicking natural disturbance patterns. Varying densities of trees would be retained within these areas, from scattered individuals to groups consisting of the largest, healthiest trees. Compared to intermediate harvest areas and untreated forests, regenerated areas would appear as openings until new trees grow to fill the site.

Table 4 below shows how many unit and acres would be in each opening and what the current and desired conditions are. Figure 8 displays the locations of the openings.

Table 4. Large openings proposed in the action alternation and associated existing/desired conditions.

Large Opening ID	Total Number of Acres	Treatment Units Included	Existing/Desired Condition
1	217.0	27, 29, 31, 32, 50, 51, 52, 53, 65	Existing Condition: Stands with up to 50 percent wl and a mix of gf, wh, DF and lpp, which represents up to 80 percent of some stands. Mountain pine beetle, root disease, and larch dwarf mistletoe are or have caused 30-90 percent mortality in DF, and LPP. Desired conditions are to promote mostly WL and WWP with PP promoted on dryer microsites within the opening. A mosaic of age and size classes will exist over time in the opening and stocking control will be utilized to prevent future stands from reaching density levels conducive to either density induced mortality or insect and disease induced mortality.
2	443.7	1, 2, 3, 21, 22, 23, 24, 43, 44, 45, 46, 47, 48,	Existing Condition: Stands with up to 50 percent wl and a mix of gf, wh, DF and lpp, which represents up to 80 percent of some stands. Mountain pine beetle, root disease, and larch dwarf mistletoe are or have caused 30-90 percent mortality in DF, and LPP. Desired

		68	conditions are to promote mostly WL and WWP with PP promoted on dryer microsites within the opening. A mosaic of age and size classes will exist over time in the opening and stocking control will be utilized to prevent future stands from reaching density levels conducive to either density induced mortality or insect and disease induced mortality.
3	123.0	4, 7, 9, 10, 11, 14, 42	Existing Condition: Stands comprised of 30-80 percent DF/ 20-70 percent pp. Less than 10 percent of GF, WL, LPP, WH, WWP. One stand in this opening has close to 50 percent WL. Root rot infections and mistletoe infections are high in DF. Mountain pine beetle has caused mortality in LPP and WL has some WL dwarf mistletoe. Many stands are multi-storied with ladder fuels extending from the forest floor to the tops of crowns. Desired conditions are to mostly promote PP and WL on restricted wetter microsites. Stocking control will be used to maintain stocking levels resistant to insect and diseases and prevent competition induces mortality.
Total	**783.7**	**30**	

It is appropriate to create large patches that are consistent with the type of disturbance native to this ecosystem (Churchill, Dalhgreen, Larson, & Franklin, 2013) . The proposed openings have a species composition that is not resilient to fire or insect and disease, mostly due to root rot in Douglas-fir, mistletoe in Douglas-fir and western larch, or stands of lodgepole pine that have greater than 80 percent mountain pine beetle mortality. Creating openings and planting them to an early seral species mix of western larch, ponderosa pine, and western white pine and maintaining them at appropriate stocking levels will create stands and a landscape better able to fend off insect and disease and survive fire.

These three openings have significant variability in terms of stocking, species composition and levels of insect and disease infection. Portions of all three units will have residual stocking levels post treatment that make them appear less like parts of openings and more like intermediate harvests that have left a stocked stand behind. Within these inclusions, planting will not take place, nor will the Forest Service intentionally seek to initiate natural regeneration. This will help to create species, age class, and structural diversity at both the unit and project scale (Turner, Donato, & Romme, 2013).

Importantly, these opening will be regenerated through planting of the early seral species western larch, ponderosa pine, and rust resistant western white pine. Restoring western white pine to the project and landscape creates resilience at a broad scale (Hines, 2013; Nuenschwander et al., 1999). Legacy structure will be maintained within these stands which also leads to more heathy and diverse stands (Franklin et al., 2007).

Fire historically created large openings within the project area. An examination of some of the largest fires during the first half of the last century within one mile of the project area reveals the magnitude of these fires, as demonstrated in Table 5. The new openings created will help to create a mosaic of age classes at the project level, which will reduce the amount of acres in the project area that are susceptible to a particular insect or disease at one time.

Table 5. Historic openings from past fire

FIREYEAR	Total acres of historic fire that occurred within 1 mile of the project area	Acres within Cruzane Project Area
1921	2709	6
1924	4216	0
1910	457093 (note: this is contiguous; therefore, goes beyond 1 mile of the project area)	3000

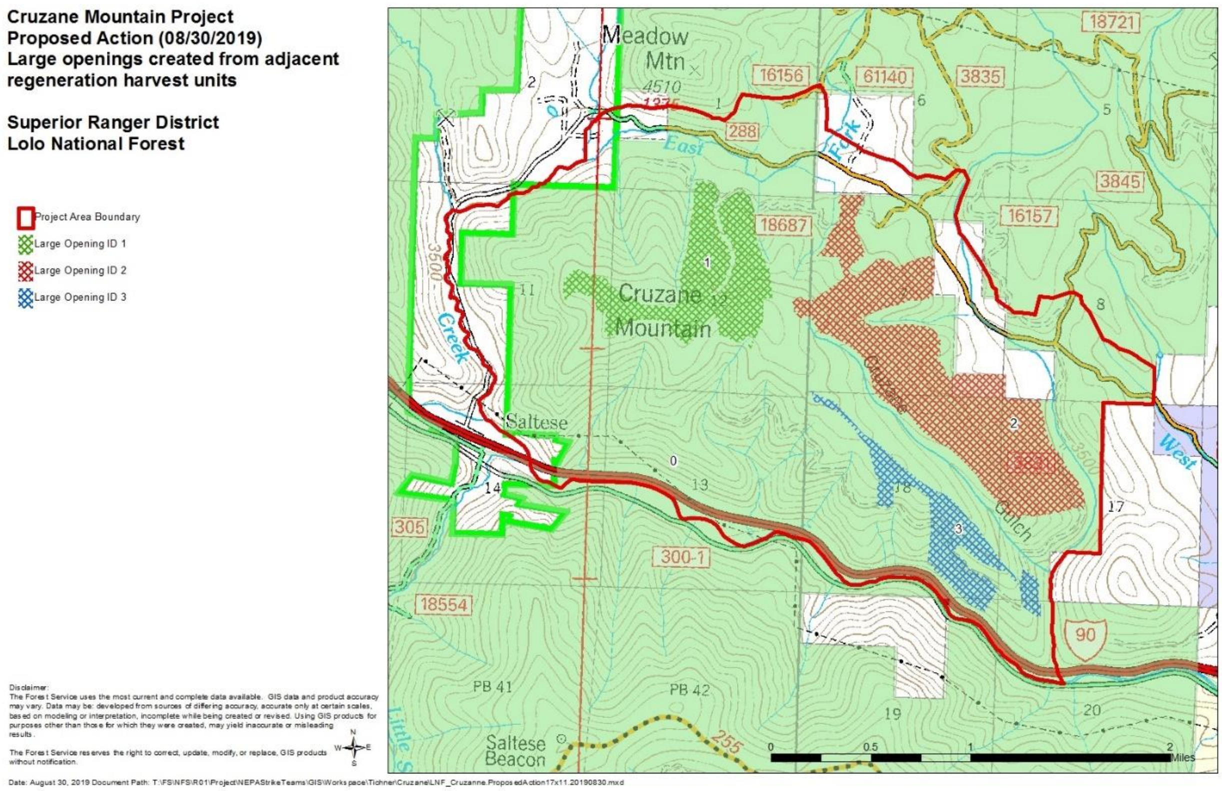

Figure 8. Greater than 40 acre openings

Effects of Ecosystem Burns

Burns planned for the south facing ponderosa pine stands will generally trend vegetation towards desired conditions by reducing the amount of smaller shade tolerant species like Douglas-fir in favor of ponderosa pine; lower overall stocking levels to make these water deficit sites have fewer trees competing for scarce water. Some desired trees may be killed in burning operations, but fire killed trees, particularly ponderosa pine are more persistent than snags created by other mortality agents; therefore, make good persistent habitat (Russell, Saab, Dudley, & Rotella, 2006).

Cumulative Effects

Past, Present, and Reasonably Foreseeable Activities Relevant to Cumulative Effects Analysis

The effects of past management are considered until those effects are no longer discernable. Existing vegetation conditions described at the beginning of this report reflect past timber harvest, stand tending, grazing, homesteading, and fire suppression and other activities that influenced forested vegetation in the project area. Appendix A displays a list of past activities that overlap in space with the Cruzane Mountain Project Area and a list of ongoing and future activities that overlap in time and space with the Cruzane Project Project Area. The past activities list is not exhaustive because there is a degradation in quality of record keeping the further back in time the Forest Service's activity database (FACTS) is queried.

For this resource analysis, the master list and a more detailed dataset that the master list was created from was reviewed and actions were chosen for this analysis based on their potential effect to the vegetation resource.

The past actions summary is not necessarily exhaustive, as records may not exist for all past activities by project. This is particularly true for those actions that predate the passage of the National Environmental Policy Act in 1970. Nonetheless, the effects of such past actions are accounted for in the assessment of the existing condition, as the current condition assessment necessarily reflects any relevant impacts of such actions. It is important to note that separate activities may have occurred on the same acreage over time.

Timber harvest occurred over approximately 30 percent of the project area from the 1950s to present to support mining, homesteading and sawmills. More recent timber harvest, where records of the activities exist, occurred from the 1960s to the current time, with the vast majority of it occurring between the 1960s and 1970s. Roughly 690 acres of regeneration harvest took place in the form of individual tree selection, shelterwood, clearcut, and seed tree cut and roughly 540 acres of intermediate harvest took place in the form of commercial thin, salvage cut, liberation cut. Pre-commercial thinning occurred over approximately 97 acres within the project area, much of this was in past commercial units.

Past timber harvest has had two main effects on forested vegetation within the project area. The first is to set successional pathways back to early seral conditions by regenerating stands and planting them to early seral species or implementing an intermediate harvest such as liberation or commercial thin which leaves mostly early seral species, which are considered desirable. In some cases, especially individual tree selection harvests, led to dysgenic selection of trees, meaning that trees of desirable species and form were taken and less desirable species were left, thus leading a degradation of genes on site. So the impact of past harvest on species composition is mixed, certain harvests promoted quality, early seral species, but some left less desirable species from early to late seral. It is difficult to discern exactly what happened where within the project area because there are a myriad of other factors that influence current species composition.

Fire suppression has probably had the greatest influence on existing stand structure, species composition, and age class distribution in the project area. There are no records, nor would it be possible for there to be any on the number of acres that were kept from burning as the result of fire suppression. That said, based on existing condition, fire suppression has dramatically increased the amount of late seral species, especially Douglas-fir and grand fir, which has subsequently increased the amount of armillaria root rot because these are the primary susceptible hosts, that existed in much lower numbers prior to active fire supression. Size class, as an average across the project area is smaller than it would have been in the presence of fire as fire tends to select for the largest trees as they are most likely to survive. Trees per acre is much higher than it historically would have been with fire present to naturally thin stands. As discussed above, a shift to later seral species and increased density has pre-disposed the project area to higher levels of insect and disease.

Ongoing and future actions include the possibility of stand tending in the form of pre-commercial thinning; commercial harvest ranging from commercial thinning to clearcutting with reserves; and continued weed management. Any harvest that takes place and follows NEPA, the Forest Plan and other relevant laws and regulations will necessarily not lead to high grading and should leave stands trending in a desirable condition in terms of species composition, density, and size class distribution. Any future prescribed burning will have a similar effect by generally killing smaller less desirable trees in favor of larger early seral species.

Fire suppression is another ongoing activity which will likely have deleterious consequences on forested vegetation within the project area, as described above in the paragraph on past fire suppression.

Resource Indicators and Measures

The resource indicators and measure for alternative 2 cumulative effects is summarized below.

Table 6. Resource indicators and measures for alternative 2 cumulative effects

Resource Element	Resource Indicator	Measure	Alternative 2 Cumulative Effects
Stand Structure/ Species Composition	Stand density Species diversity Size Class diversity	Trees per acre in dry types; Percent of landscape in non-lodgepole pine; Acres shifted to 0 to 5 inch dbh Class	All three metrics fall into range for treatment units

Summary/"So What"

In summary, the action alternative would trend the landscape towards desired conditions and meet the purpose and need by:

- Reducing stand density and increasing age class, size class, and species diversity in the project area;
- Removing ill-adapted off-site trees planted in the first half of the last century;
- Recovering the economic value of forest products to support and sustain local economies, industries, and livelihoods;
- Increasing the amount of rust resistant western white pine;
- Decreasing the amount of root rot infections;
- Reducing the amount of mistletoe in the project area.

Indirect effects of these actions would reduce the likelihood of future landscape level mountain pine beetle attacks, lower Douglas-fir beetle and western spruce budworm hazard ratings, and lower the probability of torching in multi-story stands. Table 7 provides a summary of how resource indicators will change with treatment.

Table 7. Summary of effects to resource indicators as a result of proposed vegetation management activities.

Effects of Alternatives on Resource Indicators				
Resource Element	Resource Indicator	Effect of no action alternative	Effect of action alternative ponderosa pine/Douglas-fir	Effect of action alternative western larch/western white pine
Structure	Density – BA	Highly variable,	Lowers to 40 – 80	Lowers to 40 – 80

		upper range is 150-250	square feet depending on size classes. Where insufficient desirable species exist, this could go as low as 5-10 and unit would be planted to desirable species	square feet depending on size classes. Where insufficient desirable species exist, this could go as low as 5-10 and unit would be planted to desirable species
	Density – TPA	Often multiple size classes, with multiple stories, much of the project is >200 TPA	Decreases	Decreases
	Size Class – QMD	Little representation of smallest and largest size classes, see figure 2	Increases in stands with intermediate harvest and decreases in stands with regeneration harvests	Increases in stands with intermediate harvest and decreases in stands with regeneration harvests
Species Composition	% of early seral species	High percent of late seral species, such as grand fir, hemlock, and Douglas-fir. Percent of late seral will increase as the stand moves through succession	Increases	Increases
Genetic Makeup	% off-site trees present	Highly variable, some stands have >20% off site trees, while some have none	Decreases	Decreases

Compliance with Forest and Other Relevant Laws, Regulations, Policies and Plans

Regulatory Framework

The regulatory framework that the project is conducted under is as follows. After this section will be an explanation of how the project is in compliance with relevant laws, regulations, policies, and plans.

Forest Plan

Forest wide direction indicates that:

- Increase the use of the available wood fiber consistent with management objectives and economic principles. Sufficient amounts of woody material will be left to maintain soil fertility. Management emphasis items for tools to accomplishing increased use include:
    - Regenerated stands will undergo stocking level control when:
        - Necessary to obtain future stand yields as projected in the Forest Plan yield tables. Thinning activities generally will only be undertaken when an economic analysis shows positive value increase. However, some thinning will occur where an analysis does not show a positive increase but is needed to meet future timber outputs projected in the Forest Plan. In these cases an economic evaluation will be used to determine the highest priority stands for treatment;
        - Necessary to protect stands from fire, insects, or disease where the lands are classified as suitable for timber production.
- Implementation of the principles of integrated pest management will be accomplished through sound silvicultural prescriptions. Silvicultural practices will be designed to consider past, current, and potential impacts from insects and diseases.
- Biological and vegetative management practices will be utilized to control insect and disease infestations. Chemical control will be recommended when other methods are ineffective and only after following all required procedures.

The Cruzane Mountain project contains four management areas represented in the following percentages:

Management Area (MA)	Percent within the project area	Percent of treatment units by MA
13	16	3
16	19	32
24	34	34
25	19	31
Private	12	0

Direction differs by management area.

Management Area 13 is primarily lakes, streams, and other water bodies and adjoin areas consisting mostly of riparian vegetation. There are very few acres of vegetation treatments proposed in this management area. Areas that are accessible are suitable for timber production.

Management Area 16 consists of lands of varying physical environments as determined by soil, slope, aspect, elevation, physiographic site, and climatic factors, which are suitable for timber management.

- Provide for regeneration of a mixture of species with the emphasis on maintaining the components of ponderosa pine and western larch commonly found in naturally occurring stands.

Management Area 24 consists of lands with high visual sensitivity and which are available for varying degrees of timber management.

- Provide for healthy stands of timber and optimize timber growing potential within the constraints imposed by Goal 1, while providing for dispersed recreation use opportunities, wildlife habitat, and livestock use.
- The Management Area is classified as suitable for timber production.
- Using integrated pest management techniques, efforts aimed at preventing or controlling losses from outbreak populations will be necessary at times. These efforts may include removal of highly susceptible, heavily infected, or infested individual trees.

Management Area 25 consists of lands with a medium degree of visual sensitivity and which are available for varying degrees of timber management.

- Provide for healthy stands of timber and optimize timber growing potential within the constraints imposed by Goal 1, while providing for dispersed recreation opportunities, wildlife habitat, and livestock use.

Forest Service Manuals and Handbooks

Forest Service Manual 2020 provides direction on managing for ecological restoration and resilience. It cites nineteen principle statutes and five executive orders that provide the authority to restore National Forest System lands. The aim is to reestablish and retain ecological resilience of National Forest System lands and associated resources to achieve sustainable management and provide a broad range of ecosystem services. Healthy, resilient landscapes would have greater capacity to survive natural disturbances and large scale threats to sustainability, especially under changing and uncertain future environmental conditions, such as those driven by climate change and increasing human uses.

Forest Service Manual 2470 provides broad policy guidance for silvicultural practices on the national and regional levels. Sections pertinent to this proposal include harvest cutting, reforestation, timber stand improvement, sale area improvement deposits, examinations, prescriptions and evaluations, stocking guides, and growth projections. Regional supplements include procedures for exceeding opening size limitations, and reforestation and timber stand improvement policies.

There are four handbooks which provide even greater detail than the manuals for their specific area of concern. They include the Silvicultural Practices Handbook (Forest Service Handbook 2409.17), Reforestation Handbook (Forest Service Handbook 2409.26b), Seed Handbook (Forest Service Handbook 2409.26f), Knutson-Vandenburg Fund Handbook (Forest Service Handbook 2409.19). The Timber Management Control Handbook (Forest Service Handbook 2409.21e) covers the timber resource information system. All handbooks contain large sections of Regional supplements.

Forest Service Manual 2471.1 (R1 Supplement 2400-2001-2) requires a 60-day public review and Regional Forester approval for even-aged regeneration harvest openings exceeding 40 acres.

National Laws/Regulations

Basic authority for silvicultural practices on National Forest System lands is contained in the following acts:

1. Organic Administration Act of 1897 (30 Stat. 34, as supplemented and amended; 16 U.S.C. 473-478), that states the purpose of the national forests, and directs its control and administration to be in accord with such purpose, that is, “No national forest shall be established, except to improve and protect the forest within the boundaries, or for the purpose of securing favorable conditions of water flows, and to furnish a continuous supply of timber for the use and necessities of citizens of the United States.”

2. Knutson-Vandenberg Act of 1930 (46 Stat. 527, as amended; 16 U.S.C. 576 - 576b), authorizes the Secretary of Agriculture to "...establish forest tree nurseries and do all other things needful in preparation for planting on national forests..." and requires the "purchaser of national forest timber to make deposits of money ...to cover the cost ...of planting, sowing with tree seeds, cutting, destroying, or otherwise removing undesirable trees or other growth and protecting and improving the future productivity of renewable resources..."

3. Bankhead-Jones Farm Tenant Act of 1937 (50 Stat. 525, as amended; 7 U.S.C. 1010-1012), authorizes and directs the Secretary to "...develop a program of land conservation and land utilization, in order thereby to correct maladjustments in land use, and thus assist in controlling soil erosion, reforestation, preserving natural resources..."

4. Anderson-Mansfield Reforestation and Revegetation Act of 1949 (63 Stat. 762; 16 U.S.C. 581j-581k), states "...it is the declared policy of the Congress to accelerate and provide a continuing basis for the needed reforestation and revegetation of national forest lands and other lands under administration and control of the Forest Service of the Department of Agriculture in order to obtain the benefits hereinbefore enumerated..."

5. Granger-Thye Act of 1950 (64 Stat. 82, as amended; 16 U.S.C. 490), authorizes the Secretary of Agriculture "... where the public interest justifies, to cooperate or assist public and private agencies,...in performing work...within or near a national forest for which the administering agency, owner, or other interested party deposits...a sufficient sum to cover the total estimated cost of the work to be done for the benefit of the depositor, for administration, protection, improvement, reforestation, and such other kinds of work the Forest Service is authorized to do on lands of the United States. It also "authorizes the Secretary of Agriculture, subject to such conditions as he may prescribe, to sell forest-tree seed and nursery stock..."

6. Multiple-Use Sustained-Yield Act of 1960 (Pub. L. 86-517, 74 Stat. 215; 16 U.S.C. 528-531), authorizes and directs the Secretary of Agriculture "...to develop and administer the renewable surface resources of the national forests for multiple use and sustained yield of the several products and services obtained therefrom..."

7. Supplemental National Forest Reforestation Fund Act of 1972 (87 Stat. 242, 245, as amended; 16 U.S.C. 576c-576e), directs the Secretary of Agriculture to establish a "Supplemental National Forest Reforestation Fund."

8. Forest and Rangeland Renewable Resources Planning Act of 1974, as amended by the National Forest Management Act (NFMA) of 1976 (16 U.S.C. 1600-1614), states "it is the policy of the Congress that all forested lands in the National Forest System be maintained in appropriate forest cover with species of trees, degree of stocking, rate of growth, and conditions of stand designed to secure the maximum benefits of multiple use sustained yield management in accordance with land management plans" and directs the Secretary of Agriculture to ensure that timber will be harvested from National Forest System lands only where there is assurance that such lands can be adequately restocked within five years after harvest. It provides for logging

while recognizing "the fundamental need to protect and where appropriate, improve the quality of soil, water, and air resources." It ensures that timber will be harvested from national forest lands "only where soil, slope or other watershed conditions will not be irreversibly damaged." It also specifies that "protection is provided for streams, stream-banks, shorelines, lakes, wetlands, and other bodies of water from detrimental changes in water temperatures, blockages of water courses, and deposits of sediment, where harvest are likely to seriously and adversely affect water conditions or fish habitat."

9. Reforestation Trust Fund, Title III - Reforestation, Recreation Boating Safety and Facilities Improvement Act of 1980 (16 U.S.C. 1606a, as amended), establishes "...in the Treasury of the United States a trust fund, to be known as the Reforestation Trust Fund..., consisting of such amounts as are transferred to the Trust Fund under Subsection (b) (1)..."

10. Healthy Forests Restoration Act (HFRA) of 2003 (16 U.S.C. at 1611-6591), provides processes for developing and implementing hazardous fuel reduction projects on certain types of "at-risk" National Forest System and Bureau of Land Management (BLM) lands, and also provides other authorities and direction to help reduce hazardous fuel and restore healthy forest and rangeland conditions on lands of all ownerships.

National Forest Management Act

The National Forest Management Act (number 8 in the list above), U.S. Public Law 94-588, 1976; is the principal law governing vegetation management treatments on National Forest System lands. Below is a further explanation of how the law affects the vegetation resource.

This project is consistent with the National Forest Management Act. Treated stands would be more resilient to insect, disease, and fire post-harvest; therefore, more likely to maintain appropriate forest cover and appropriate stocking levels than they would have been prior to treatment. Intermediate harvest units would be stocked immediately post-harvest; units receiving regeneration harvest would be stocked within five years, this would be checked by one, three, and five year regeneration stocking surveys.

1. Suitability for Timber Production: No timber harvest, other than salvage sales or sales to protect other multiple-use values, shall occur on lands not suited for timber production (16 USC 1604(k)).

   All units in the Cruzane Mountain Project are on lands suitable for timber production.

2. Timber Harvest on National Forest Lands (16 USC 1604(g)(3)(E)): A Responsible Official may authorize site-specific projects and activities to harvest timber on National Forest System lands only where:

   a. Soil, slope, or other watershed conditions will not be irreversibly damaged (16 USC 1604(g)(3)(E)(i)).

      Watershed conditions have been evaluated and it has been determined that with design criteria they will not be irreversibly damaged by full implementation of this project.

   b. There is assurance that the lands can be adequately restocked within five years after final regeneration harvest (16 USC 1604(g)(3)(E)(ii)).

      On the Lolo National Forest, from 1976 to 2016, the latest year data is available for, the Superior Ranger District has been 98% successful in regenerating harvested stands. Stands prescribed for regeneration harvest will be inspected for stocking at years 1, 3 and 5 following harvest.

c. Protection is provided for streams, streambanks, shorelines, lakes, wetlands, and other bodies of water from detrimental changes in water temperatures, blockages of water courses, and deposits of sediment, where harvests are likely to seriously and adversely affect water conditions or fish habitat (16 USC 1604(g)(3)(E)(iii)).

   Refer to the project file under hydrology and fisheries analysis for project specific protection requirements and rules and laws applicable to this resource.

d. The harvesting system to be used is not selected primarily because it will give the greatest dollar return or the greatest unit output of timber (16 USC 1604(g)(3)(E)(iv)).

   Selection of harvest system is based on how to most effectively meet the project's purpose and need.

3. Clearcutting and Even-aged Management (16 USC 1604(g)(3)(F)): Insure that clearcutting, seed tree cutting, shelterwood cutting, and other cuts designed to regenerate an even aged stand of timber will be used as a cutting method on National Forest System lands only where:

   a. For clearcutting, it is determined to be the optimum method, and for other such cuts it is determined to be appropriate, to meet the objectives and requirements of the relevant land management plan (16 USC 1604(g)(3)(F)(i)).

   b. The interdisciplinary review as determined by the Secretary has been completed and the potential environmental, biological, esthetic, engineering, and economic impacts on each advertised sale area have been assessed, as well as the consistency of the sale with the multiple use of the general area (16 USC 1604(g)(3)(F)(ii)).

   c. Cut blocks, patches, or strips are shaped and blended to the extent practicable with the natural terrain (16 USC 1604(g)(3)(F)(iii)).

   d. Cuts are carried out according to the maximum size limit requirements for areas to be cut during one harvest operation, provided, that such limits shall not apply to the size of areas harvested as a result of natural catastrophic conditions such as fire, insect and disease attack, or windstorm (FSM R1 supplement 2400-2001-2 2471.1, 16 USC 1604(g)(3)(F)(iv)).

   e. Such cuts are carried out in a manner consistent with the protection of soil, watershed, fish, wildlife, recreation, and esthetic resources, and the regeneration of the timber resource (16 USC 1604(g)(3)(F)(v)).

      In areas where regeneration harvest is planned, it has been determined to be the most appropriate harvest technique to meet the project purpose and need. All units have been reviewed by the interdisciplinary team and treatments determined to be appropriate. The landscape architect will work with implementation foresters to ensure regeneration harvests look as natural as possible.

4. Stands of trees are harvested according to requirements for culmination of mean annual increment of growth (16 USC 1604(m)).

> Stands of trees that are to be regenerated have reached culmination of mean annual increment. Most of the stands proposed for regeneration harvest are over 100 years old. Page C-5-1 of the Forest Plan indicates that culmination on suitable lands generally happens at year 85, so these stands have reached CMAI. There are stands that will be prevented from reaching CMAI due to the persistent thinning effects of persistent root rot and/or mistletoe infections. NFMA provides exceptions from the CMAI requirement and only generally requires that stands meet CMAI, further Forest Plan Standard 57 allows ".... vegetation management practices will be utilized to control insect and disease infestations."

Also, harvest would not irreversibly damage water, soil, or air resources as demonstrated in the aquatics and soils reports. Design criteria are present to prevent detrimental changes to water courses and fish habitat.

The Cruzane Mountain Project is in compliance with federal law, forest plan standards, and Forest Service Handbook and Manual direction. The Cruzane Mountain project is in compliance with and consistent with the Forest Plan standards and objectives, as shown in Appendix B of the environmental assessment.

Literature Cited

Applegate, V., Atkins, D., Ford, G., Berglund, D., Johnson, J., Kuennen, L., . . . Zack, A. (1997). *Biophysical classification habitat groups and descriptions*. U.S. Department of Agriculture, Forest Service

Arno, S. F., Smith, H. Y., & Krebs, M. A. (1997). *Old growth ponderosa pine and western larch stand structures: Influences of pre-1900 fires and fire exclusion* (Research Paper INT-RP-495). Retrieved from Ogden, UT:

Barber, J., Berglund, D., & Bush, R. (2009). *The Region 1 existing vegetation classification system and its relationship to inventory data and the Region 1 existing vegetation map products* (09-03 5.0). Retrieved from Missoula, MT: http://fsweb.r1.fs.fed.us/forest/inv/classify/r1_ex_veg_cmi_4_09.pdf

Barber, J., Bush, R., & Berglund, D. (2011). *The Region 1 existing vegetation classification system and its relationship to Region 1 inventory data and map products* (Numbered Report 11-10). Retrieved from Missoula, MT: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5332073.pdf

Barrett, S. W., Arno, S. F., & Key, C. H. (1991). Fire regimes of western larch - lodgepole pine forests in Glacier National Park, Montana. *Candian Journal of Forest Restoration, 21*, 1711-1720.

Bell Randall, C. (2004). *Western Pine Beetle Management*. Retrieved from

Burns, R. M., & Honkala, B. H. (1990). *Silvics of North America Volume 1: Conifers [online]* (Agriculture Handbook 654). Retrieved from Washington, DC: https://www.na.fs.fed.us/spfo/pubs/silvics_manual/table_of_contents.htm

Charnley, S., Spies, T. A., Barros, A. M. G., White, E. M., & Olsen, K. A. (2017). Diversity in forest management to reduce wildfire losses: implications for resilience. *Ecology and Society, 22*(1), 22. doi:10.5751/es-08753-220122

Churchill, D. J., Dalhgreen, M. C., Larson, A. J., & Franklin, J. F. (2013). *The ICO approach to restoring spatial pattern in dry forests: Implementation guide* (Version 1.0). Retrieved from Vashon, WA:

Finkeldey, R., & Ziehe, M. (2004). Genetic implications of silvicultural regimes. *Forest Ecology and Management, 197*(1-3), 231-244. doi:10.1016/j.foreco.2004.05.036

Fischer, W. C., & Bradley, A. F. (1987). *Fire ecology of western Montana forest habitat types* (General Technical Report INT-223). Retrieved from Ogden, UT:

Fitzgerald, S. A. (2005). *Fire ecology of ponderosa pine and the rebuilding of fire-resilient ponderosa pine ecosystems* (General Technical Report . PSW-GTR-198). Retrieved from

Franklin, J. F., Mitchell, R. J., & Palik, B. J. (2007). *Natural disturbance and stand development principles for ecological forestry* (General Technical Report NRS-19). Retrieved from Newtown Square, PA: https://www.nrs.fs.fed.us/pubs/3293

Franklin, J. F., Spies, T. A., Van Pelt, R., Carey, A. B., Thornburgh, D. A., Berg, D. R., . . . Chen, J. (2002). Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example. *Forest Ecology and Management, 155*(1-3), 399-423. doi:http://dx.doi.org/10.1016/S0378-1127(01)00575-8

Gibson, K. (2009). *Bark beetle conditions northern region 2008*. Retrieved from

Gibson, K. E. (2004). *Mountain pine beetle management*. Retrieved from

Gillette, N. E., Wood, D. L., Hines, S. J., Runyon, J. B., & Negrón, J. F. (2014). The once and future forest: Consequences of mountain pine beetle treatment decisions. *Forest Science, 60*(3), 527-538. doi:10.5849/forsci.13-040

Green, P., Joy, J., Sirucek, D., Hann, W., Zack, A., & Naumann, B. (1992). *Old-growth forest types of the northern region* (R-1 SES 4/92). Retrieved from Missoula, MT:

Hadley, K. S., & Veblen, T. T. (1993). Stand response to western spruce budworm and Douglas-fir bark beetle outbreaks, Colorado Front Range. *Canadian Journal of Forest Research, 23*(3), 479-491. doi:10.1139/x93-066

Hagle, S. (2004). *Management guide for root disease*. Retrieved from

Hagle, S. K., Schwandt, J. W., Johnson, T. L., Kegley, S. J., Randall, C. S. B., Taylore, J. E., . . . Marsden, M. A. (2000). *Succession functions of forest pathogens and insects, Ecosections M332a and M333d in northern Idaho and western Montana. Volume 2: Results and Conclusions* (FHP Report No. 00-11). Retrieved from Missoula, MT:

Hawksworth, F. G. (1977). *The 6-class dwarf mistletoe rating system* (RM-48). Retrieved from Fort Collins, Colorado:

Helms, J. A. (1998). *The dictionary of forestry*: Society of American Foresters.

Hessburg, P. F., Agee, J. K., & Franklin, J. F. (2005). Dry forests and wildland fires of the inland northwest USA : Contrasting the landscape ecology of the pre-settlement and modern eras. *Forest Ecology and Management, 211*, 117-139. doi:http://dx.doi.org/10.1016/j.foreco.2005.02.016

Hines, S. (2013). Return of the King: Western White Pine Conservation and Restoration in a Changing Climate. *Science You Can Use*(4).

Hoffman, J. (2004). *Elytroderma needle cast*. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region

Hoffman, J. (2010). *Dwarf mistletoe management*. Retrieved from

Howe, G. E. (1995). *Exotic and non-local seed source plantations on the Superior Ranger District*. (MFO-TR-95-05). Missoula, MT: U.S. Department of Agriculture, Forest Service, Forest Health Protection

Kegley, S. (2011). Douglas-fir beetle management: Dendroctonus pseudotsugae Hopkins.

Larson, A. J., Belote, R. T., Cansler, C. A., Parks, S. A., & Dietz, M. S. (2013). Latent resilience in ponderosa pine forest: effects of resumed frequent fire. *Ecological Applications, 23*(6), 1243-1249.

Losensky, B. J. (1993). *Historical vegetation in region one by climatic section*. Retrieved from Missoula, MT:

Maloy, O. C. (2001). White pine blister rust. *Plant Health Progress, 2*(1). doi:10.1094/php-2001-0924-01-hm

Milburn, A., Bollenbacher, B., Manning, M., & Bush, R. (2015). *Region 1 existing and potential vegetation groupings used for broad-level analysis and monitoring*. Retrieved from Missoula, MT: http://fsweb.r1.fs.fed.us/forest/inv/r1_tools/R1_allVeg_Groups.pdf

Naficy, C., Sala, A., Keeling, E. G., Graham, J., & DeLuca, T. H. (2010). Interactive effects of historical logging and fire exclusion on ponderosa pine forest structure in the northern Rockies. *Ecological Applications, 20*(7), 1851-1864. doi:http://dx.doi.org/10.1890/09-0217.1

Newton, A. C., & Cantarello, E. (2015). Restoration of forest resilience: An achievable goal? *New Forests, 46*(5-6), 645-668. doi:10.1007/s11056-015-9489-1

Nuenschwander, L. F., Byler, J. W., Harvey, A. E., McDonald, G. I., Ortiz, D. S., Osborne, H. L., . . . Zack, A. (1999). *White pine in the American west: A vanishing species - can we save it?* (RMRS-GTR-35). Retrieved from

Oliver, C. D., & Larson, B. C. (1996). *Forest stand dynamics* (Update ed.). New York, NY: John Wiley and Sons.

Pederson, L., Sturdevant, N., & Blackford, D. (2011). *Western spruce budworm management*. Retrieved from

Pfister, R. D., Kovalchik, B. L., Arno, S. F., & Presby, R. C. (1977). *Forest habitat types of Montana* (General Technical Report INT-34). Retrieved from Ogden, UT: https://www.fs.fed.us/rm/pubs_int/int_gtr034.pdf

Randall, C. B. (2012). *Management guide for fir engraver Scolytus ventralis (LeConte)*. Missoula, MT: U.S. Department of Agriculture, Forest Service

Reukema, D. L., & Bruce, D. (1977). *Effects of thinning on yield of douglas-fir: Concepts and some estimates obtained by simulation*. (USDA Forest Service General Technical Report PNW-58). Portlandl, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station

Russell, R. E., Saab, V. A., Dudley, J. G., & Rotella, J. J. (2006). Snag longevity in relation to wildfire and postfire salvage logging. *Forest Ecology and Management, 232*(1–3), 179-187. doi:http://dx.doi.org/10.1016/j.foreco.2006.05.068

Schwandt, J. W., Kearns, H. S. J., & Byler, J. W. (2013). *White pine blister rust: General ecology and management*. (Forest Health Protection Report Number 13-07). Washington, DC: U.S. Department of Agriculture, Forest Service, Forest Health Protection

Swanson, M. E., Franklin, J. F., Beschta, R. L., Crisafulli, C. M., DellaSala, D. A., Hutto, R. L., . . . Swanson, F. J. (2011). The forgotten stage of forest succession: early-successional ecosystems on forest sites. *Frontiers in Ecology and the Environment, 9*(2), 117-125. doi:http://dx.doi.org/10.1890/090157

Turner, M. G., Donato, D. C., & Romme, W. H. (2012). Consequences of spatial heterogeneity for ecosystem services in changing forest landscapes: priorities for future research. *Landscape Ecology, 28*(6), 1081-1097. doi:http://dx.doi.org/10.1007/s10980-012-9741-4

Turner, M. G., Donato, D. C., & Romme, W. H. (2013). Consequences of spatial heterogeneity for ecosystem services in changing forest landscapes: Priorities for future research. *Landscape Ecology, 28*(6), 1081-1097. doi:http://dx.doi.org/10.1007/s10980-012-9741-4

U.S. Department of Agriculture, Forest Service. (1997). *Lolo National Forest dead down habitat components guidelines*. Retrieved from

U.S. Department of Agriculture, Forest Service. (2014). *FSM 2400 - forest managment chapter 2470 - silvicultural practices*. Washington, DC: U.S. Department of Agriculture, Forest Service

U.S. Department of Agriculture, Forest Service. (2015). *FSH 1909.12 – Land management planning handbook: Chapter - Zero code*. (1909.12-2015-1). Washington, DC: U.S. Department of Agriculture, Forest Service Retrieved from https://www.fs.fed.us/im/directives/